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Research Article

Enhancing productivity of ethiopian footwear industry by integrating of work measurement with line balancing techniques

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Abstract

The footwear industry is one of the most economic sectors, which should be given attention for the development of the Ethiopian country and it needs to enhance its productivity by reducing the major factors that affect its productivity. In this paper, the major factors raised are high cycle time, bottleneck process, less line efficiency, less output per day, less labor productivity, and distance movement of workers. Those factors are reduced and enhanced productivity through work measurement and line balance. The result of the study is increased line efficiency of the cutting, stitching, and lasting and finishing section to 80.76%, 76.8%, and 75.50% and output per day in pairs are 714, 625.3, and 623 with the increased labor productivity per day in pair is to 34, 12.3, and 12.7 respectively. The enhanced productivity of finished footwear products is to 623 pairs with additional production of 160 pairs of shoes per day and actual finished shoe output performance is increased by 23%.

Keywords:
Enhancing productivity;
footwear industries;
work measurement;
Line balance..

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1. Introduction

Productivity is widely accepted as one of the most important and it constantly improves productivity in the manufacturing industry (Naveen, 2014), (Michael, 1990), and enhances productivity used in satisfying customers more than others (Gonfa, 2012), (Batool, 2015). As the customer's demand is high it requires the firm to increase productivity (Singh, 2016). Since Ethiopia is one of the developing countries in the world, enhancement of productivity is unquestionable for every sector (Abebe, 2012) and it needs improvements (PSI, 2020).

Footwear is an active product (Tesfaye, 2009) and one of the strategic industrial development plans of the Ethiopian country (Bezaneh, 2017) and the productivity of the footwear sector are low even though the sector is growing (Gebreslassie, 2015). The footwear industry is one of the many economic sectors, which should be given attention for the development of the country (Teklemariam, 2004), (Gonfa, 2012), it has a huge potential for boosting the country's economy and it needs consideration (Tomas, 2018), (Cherkos, 2011), (Tessema, 2007) . the actual export is much less than that of the target export plan of the country on finished footwear of a country with low performance (Embassy of Japan, 2008), (UNIDO, 2012), this indicates its requirement for improvement and enhance the productivity of footwear sector (Etefa, 2018), (Bezaneh, 2017). The labor productivity of Ethiopia is much lower than that of other industrializing countries such as Vietnam, Cambodia, Myanmar, and Tanzania with 3.4, 2.9, 1.7, and 1.6 times higher, respectively than that Ethiopia. Even Kenya's labor productivity is 3 to 4 times higher than that of Ethiopia and it needs to improve productivity (PSI, 2020).

The productivity of footwear industries is affected due to less line efficiency and labor productivity (Bezaneh, 2017), inefficient work procedures and unwanted movement and customers dissatisfaction (Raju, 2008), improper flow process (Tessema, 2007), and poor training (Woldegebriel, 2013) , high cycle time, and waiting time (idle time) with workers (Batool, 2015) and Such problems reduce through the application of work measurement and line balance to enhance their productivity. Proper doing of workers plays a great role to achieve on increasing the productivity of the company (Tessema, 2007).

2. Literature Review

Productivity as a measure of output and important in industry and also enhance productivity is important for the stakeholders of the organization and country (Sanjay, 2016), (Satbir, 2016). In sub-Saharan countries including Ethiopia shoe factories have labor-intensive and it's a major economic activity of countries and it needs to produce more products to satisfy the customers (Tetsushi,2008), (Carlos,2005), (Jared,2016).

Enhancing productivity is making the production processes of firms and industries more efficient and productive (Ewert, 2016) and it needs to improve and update the processing time and working conditions of the organization (Jared,2016) and also tasks (activities) or working conditions of the workers can create value for a company (Gündüz, 2003), the overall productivity is low due to less output per day (Tiziana, 2010), (Batool, 2015) , Less labor productivity (Hadi, 2013), Improper working conditions, and movement of the workers with Improper process flow (Jian, 2014), Customer dissatisfaction (Lee, 2014), Ineffective process time (Everette, 2000), Existence of bottleneck with idle and maximum cycle time in the process (Batool, 2015), (Mahathir, 2019). To enhance the productivity of the Ethiopian footwear industries, it needs to improve overall productivity, labor productivity, process flow, and working conditions of the workers in each footwear industry that existed in the country and through acts and apply new ways of doing things (Michael, 1990)

Work measurement: is concerned with investigating and eliminating production loss time and improving the worker's ways of doing the job (Mohd, 2005), (Rahul, 2014).

Time Study: is the analysis of a specific job by a qualified worker to find the most efficient method in terms of time and effort (Patange, 2013), (Muthamizhmaran, 2016)

Performance rate (PR): is the value describing the rate at which an operator is performing. Most of the companies used as the standard performance rating are between 85 % - 100% with it depending on the existed conditions of the sectors (Kanawa, 1992), (Abed, 2015)

Allowance (A): A value describing how the normal time will change, based on fatigue and personal needs of the operator. The basic allowance industry sectors with their standard allowances for Personal and relaxation allowance is between 7% - 12%, fatigue 5 % - 7% contingency 2 % - 6% and delay 5% (Abed, 2015).

In both cases of the PR and A, there is a critically studied and recorded in each section of the case study of the company, then it compares with the existed standard and uses ST analyses and calculation. It's different in each section and taken and used the average of the overall analysis and constant depends on the section. The process and the adjustment are calculated by determining if the operator was moving at a fast or slow pace.

Line balance: assigning a proper number of workers or machines for each operation to meet the required production rate is an effective tool to improve productivity (Niaz, 2014).

Cycle time is the time required for the job to go through the factory and it depends on the time consumed in the given operation (Toly, 2013), (Tim, 2004)

3. Research Methodology

3.1 Data source, collection and record

Different data is identified and used as input for the methodology of the research. This research methodology includes primary and secondary data collection methods. Collect and record exist all operations, operation time, number of labor, and all allowances with their performance rate. Then find the normal time, Standard time, output per labor, and cycle time of each operation. In the end, identify operations has high cycle time with less output per day and find the cause of consuming high cycle time and find a solution for each operation.

3.2 Overall tools, software, and materials used

Using a stopwatch to measure (observe) the production time that each, a time study sheet for record and analyzing each time of the tasks, a flow process chart for showing the process and operations, distance measurement material (BM tools), which used for measuring distance movement of workers, Flex Sim 2021 software for showing an arrangement of the process flow of the section and Microsoft Office 2013 Excel to detail analysis the recorded data and bar graphs for comparing the exist and proposed system with their result.

3.3 Basic formula

Observed Time (OT): The exact amount of time that the operation process is to be completed and also during the record of the processing time it's better to record 10 times to 15 times of the single given process (Misganaw, 2016). During record time it observes and records both shifts (morning and afternoon), which means five times at the morning working time and five times at afternoon working time. Because more than one operation is operated by a single operator and it needs a difference in the operation time when it works for a long time.

Av. OT = $(T_1 + T_2 + T_3 + \ldots T_n)/n$. …(1)

Normal time (NT) is the average observed time * performance rate (Kanawa, 1992)

NT = Av.OT * PR …… (2)

The allowance factor (AF) = NT*A…. (3)

Standard time: is calculated using normal time that considers allowance based on worker conditions (Kanawa, 1992), (Aldri, 2017)

Then the standard time, line efficiency, and output per labor are calculated through different formulas (Ayatullah, 2019), (Mulat, 2019), (Sobur, 2015)

Standard time (ST) = NT+AF …… (4)

Line efficiency (L_{eff}) = [(T_{CT}) / (N_{op} *M $_{CTof\ operation\ in\ the\ section}$)]*100 ….(5)

Capacity per day = [(28800/ST)*lbr]..(6)

Total output ($T_{O/P}$) = (Total number of labour in a line * available time(min) * line efficiency) / total standard time). Then,

$T_{O/P} = (T_{(LB)} * A_T * L_{eff}) /ST$……(7)

Output per labor (O/P /Lbr) = total output per day/total number of labor in a line. Then,

$O/P /Lbr = T_{(O/P)} / T_{(Lbr)}$ ……(8)

Cycle time (CT) = ST / Lbr …… (9) (Toly, 2013), (Tim, 2004)

4. Data analysis and Finding

Data analysis included cycle time, bottleneck operation, line efficiency, labor output, and total output per day of each section. High cycle time indicated that the operation consumes high operation time and bottleneck operations are that operation has a high cycle time and there is a waiting time before those bottleneck operations. Line efficiency depends on the total cycle time including maximum cycle time and the number of operations and it is used to identify and determine the efficiency of each line of the production. High line efficiency indicates that the production process of that line is good than those has less line efficiency.

In cutting section 19 operation process with 60m distance movement and 240 second movement time. Among operation process upper collecting and insole, collect is unwanted activity and there is PR 92% and total A of 22% used and taken from recorded in each section of the company in table 1.

Table 1
Major calculated terms of cutting section

Operation	**AV.OT**	**NT**	**AF**	**ST**	**O/P**	**labor**	**CT**
upper raw material preparation	48.0	44.16	9.72	53.88	534.57	1	53.875
pre-cutting operation	55.2	50.78	11.17	61.96	929.68	2	30.978
back box skiving	38.0	34.96	7.69	42.65	1350.49	2	21.326
stamping	55.0	50.60	11.13	61.73	933.07	2	30.866
Upper collect	38.1	35.05	7.71	42.76	673.47	1	42.763
upper arrange and dispatch	58.0	53.36	11.74	65.10	884.80	2	32.550
insole material preparation	30.1	27.69	6.09	33.78	852.47	1	33.784
cutting texn board	30.0	27.60	6.07	33.67	855.31	1	33.672
cutting shank board	29.2	26.86	5.91	32.77	878.74	1	32.774
shank grooving	28.2	25.94	5.71	31.65	909.90	1	31.652
shank skiving	31.3	28.80	6.34	35.13	819.79	1	35.131
attaching shank	25.7	23.64	5.20	28.85	998.42	1	28.846
apply glue	31.0	28.52	6.27	34.79	827.72	1	34.794
molding	28.8	26.50	5.83	32.33	890.95	1	32.325
beveling	25.3	23.28	5.12	28.40	2028.40	2	14.198
Insole collect	44.8	41.22	9.07	50.28	1145.50	2	25.142
insole arrange and dispatch	35.8	32.94	7.25	40.18	716.74	1	40.182
count and overall dispatch	28.0	25.76	5.67	31.43	916.40	1	31.427
overall inspection	35.3	32.48	7.14	39.62	726.89	1	39.621
Total				**780.97**		**25**	**625.906**

Line efficiency = [(625.906 second) / (19 * 53.875 second)] *100 = 61.1%

Total output per day = (25 * 28800 * 0.611 /780.97second = 563 pair/day

Output per labour = 563/25 = 22.5 pairs/ labour/ day

The major bottleneck operations and unwanted activity in

the cutting section: Upper raw material preparation, upper collect, back box skiving, bevelling, and insole collect are those needs to reduce distance with labor and add at the place where it required.

Stitching Section: It has 37 operations with a distance movement of 83.5m and movement time of 334 seconds. The PR is 87% and total A is 22% taken from recorded in each section of the company and used for table 2.

Table 2
Major calculated terms of stitching section

Operation	**AV.OT**	**NT**	**AF**	**ST**	**O/P**	**labor**	**CT**
Loading	56.8	49.416	10.87	60.288	477.71	1	60.288
Marking	71	61.77	13.59	75.359	382.17	1	75.359
skiving and quarter lining	56.1	48.807	10.74	59.545	483.67	1	59.545
attach nylon and reinforcement	52.4	45.588	10.03	55.617	1035.65	2	27.809
attach textile adhesive	32.2	28.014	6.16	34.177	1685.34	2	17.089
decorative stitch on quarter	46.7	40.629	8.94	49.567	1162.05	2	24.784
stitch back count lining	43.5	37.845	8.33	46.171	1247.54	2	23.085
stitch mudguard lining and counter	35.6	30.972	6.81	37.786	762.19	1	37.786
apply glue and attach apron	75.5	65.685	14.45	80.136	359.39	1	80.136
apply glue and attach mudguard	75.2	65.424	14.39	79.817	360.82	1	79.817
re-cut apron and mudguard	36.5	31.755	6.99	38.741	743.40	1	38.741
marking mudguard	31.2	27.144	5.97	33.116	869.68	1	33.116
skiving vamp with its lining	37.5	32.625	7.18	39.803	723.57	1	39.803
stitch mudguard with lining	28.3	24.621	5.42	30.038	1917.60	2	15.019
stitch apron with its lining	31	26.97	5.93	32.903	875.29	1	32.903
apply glue and attach back count	75.1	65.337	14.37	79.711	361.30	1	79.711
stitch back count with quarter	31.5	27.405	6.03	33.434	861.40	1	33.434
stitch complete quarter and lining	55	47.85	10.53	58.377	493.34	1	58.377
insert collar foam by applying glue	49.8	43.326	9.53	52.858	544.86	1	52.858
Turning	51.5	44.805	9.86	54.662	1053.75	2	27.331
hammering around collar	31	26.97	5.93	32.903	1750.58	2	16.452
in process quality inspection	30.5	26.535	5.84	32.373	889.64	1	32.373
stitch around eye stay and collar	55.7	48.459	10.66	59.120	974.29	2	29.560
trimming around eye stay and apron	36.2	31.494	6.93	38.423	1499.11	2	19.211
skiving 45 degree for mudguard	35	30.45	6.70	37.149	1550.51	2	18.575
punch eyelet place	55.1	47.937	10.55	58.483	492.45	1	58.483
apply glue and attach quarter	75	65.25	14.36	79.605	361.79	1	79.605
stitch quarter over mudguard	43.9	38.193	8.40	46.595	1854.26	3	15.532
trimming around quarter lining	34	29.58	6.51	36.088	798.06	1	36.088
stitch quarter lining bottom	32	27.84	6.12	33.965	847.94	1	33.965
punch closed hole	39	33.93	7.46	41.395	695.74	1	41.395
insert counter by applying glue	41.2	35.844	7.89	43.730	1975.77	3	14.577
cutting and cleaning excess thread	75.6	65.772	14.47	80.242	358.91	1	80.242
burning the excess thread	35	30.45	6.70	37.149	775.26	1	37.149
temporary shoe lacing	36	31.32	6.89	38.210	753.72	1	38.210
final QC	36.2	31.494	6.93	38.423	749.56	1	38.423
Total				945.66		53	1499.56

Line efficiency = [(1499.56 second) / (37* 80.242second)] *100 = 50.5%

Total output per day = (53 * 28800 * 0.505) / 1804.168 second = 427pair per day and Output per labour = 427/53 = 8.1 pairs/ labour/ day

The major bottleneck operations in the stitching section: Depend on the capacity output per day identified as those that produce less amount of output when compared with others. It means, that those identified bottlenecks operations are those that require high cycle time than the operations of the other, and as a section identified bottlenecks operations affect the overall output of the section because there is no smooth flow operation and major bottlenecks operations are listed in table3.

Table 3
Identified major bottleneck operations in the stitching section

Operations	Capacity	CT(sec)
Loading	477.71	60.288
Marking	382.17	75.359
skiving and quarter lining	483.67	59.545
apply glue and attach the apron	359.39	80.136
apply glue and attach the mudguard	360.82	79.817
apply glue and attach back count	361.30	79.711
stitch complete quarter and quarter lining	493.34	58.377
insert collar foam by applying glue	544.86	52.858
punch eyelet place	492.45	58.483
apply glue and attach a quarter	361.79	79.605
cutting and cleaning excess thread	358.91	80.242

Lasting and finishing section: It has 35 operation processes with a total movement distance of 83m and movement time is 332 seconds and flow process. The value of PR is 87% and A is 21% for table 4.

Table 4
Major calculated terms of lasting and finishing section

Operation	**AV.OT**	**NT**	**AF**	**ST**	**O/P**	**labor**	**CT**
last loading and insole	60.5	52.635	11.05	63.69	1356.61	3	21.229
last cleaning	30.6	26.622	5.59	32.21	894.06	1	32.213
loading upper, toe cap steel	55.6	48.372	10.16	58.53	984.11	2	29.265
roughing around centre of out sole	37	32.19	6.76	38.95	739.41	1	38.950
out sole cleaning	36	31.32	6.58	37.90	759.95	1	37.897
attaching insole on last	30.4	26.448	5.55	32.00	899.94	1	32.002
back part molding	55.3	48.111	10.10	58.21	494.72	1	58.214
insert to steam	37	32.19	6.76	38.95	739.41	1	38.950
insert last and side closing	66	57.42	12.06	69.48	414.52	1	69.478
apply glue on sides of the upper	36.2	31.494	6.61	38.11	755.752	1	38.108
insert to steam	55.5	48.285	10.14	58.42	985.88	2	29.212
creaming on upper and heat tunnel	60.7	52.809	11.09	63.90	901.42	2	31.949
pounding	30.5	26.535	5.57	32.11	896.99	1	32.107
in process quality inspection	35.5	30.885	6.49	37.37	770.65	1	37.371
first level upper roughing	34.2	29.754	6.25	36.00	799.95	1	36.002
second level upper roughing	36.8	32.016	6.72	38.74	743.43	1	38.739
first adhesive coating on upper	65.2	56.724	11.91	68.64	419.60	1	68.636
first adhesive coating on out sole	37	32.19	6.76	38.95	739.41	1	38.950
second adhesive and sole	35.3	30.711	6.45	37.16	775.02	1	37.160
sole and upper dryer	33.5	29.145	6.12	35.27	816.66	1	35.265
sole and upper re-activator	35	30.45	6.39	36.84	1563.33	2	18.422
attaching sole with upper	61.3	53.331	11.20	64.53	446.30	1	64.531
attaching sole and pressing	100.8	87.696	18.42	106.11	542.82	2	53.056
remove temporary shoe lacing	36.1	31.407	6.60	38.00	1515.69	2	19.001
de-lasting	44.6	38.802	8.15	46.95	613.41	1	46.950
cleaning excess glue	66.2	57.594	12.09	69.69	1239.80	3	23.230
ironing to remove wrinkle	60	52.2	10.96	63.16	911.94	2	31.581
painting on over rough place	35	30.45	6.39	36.84	1563.33	2	18.422
apply cream on upper	31.8	27.666	5.81	33.48	860.32	1	33.476
apply glue and insert sock lining	45.5	39.585	8.31	47.90	1202.56	2	23.949
shoe lacing	66	57.42	12.06	69.48	414.52	1	69.478
inserting tissue paper	61	53.07	11.14	64.21	1345.49	3	21.405
final brushing for shine	35.4	30.798	6.47	37.27	1545.66	2	18.633
final quality inspection	41.2	35.844	7.53	43.37	664.03	1	43.371
Arrangement and pack	36	31.32	6.58	37.90	1519.90	2	18.949
Total				1710.32		52.00	1286.15

Line efficiency = [(1286.15 second)/ (35 * 69.478 second)] *100 = 52.89%
Total output per day = (0.5289* 52 * 28800) / 1710.32second = 463 pairs per day
Output per labour = 463 pairs per day /52 = 8.9 pair per day per labour.

Identified those that produce less amount output when compared with others. It means, that those identified bottlenecks operations are those that require high cycle time than the operations of the other, and as a section identified bottlenecks operations affect the overall output of the section because there is no smooth flow operation and major bottlenecks operations are listed in table5.

Table 5
Selected Major bottleneck operations in the lasting and finishing section

Operations	Capacity	CT(sec)
back part molding	494.72	58.214
insert last and side closing	414.52	69.478
the first adhesive coating on upper	419.60	68.636
attaching sole with upper	446.30	64.531
attaching sole with upper and pressing	542.82	53.056
de-lasting	613.41	46.950
shoe lacing	414.52	69.478
final quality inspection	664.03	43.371

5. Proposed result and Discussion

5.1 . Basic ways and steps of enhancement of productivity.

In the study, the major factors affect productivity and it needs to reduce those factors to improve the productivity of the organization. Reduce distance movement of the workers with unwanted activities because those are the cause of bottleneck of operation and fatigue of workers due to this it affects cycle time of the operation process. It needs to reduce those factors to enhance the overall productivity of the company. Also, improve and increase supportive of the productivity enhancements include proper flow process, increase line efficiency of each section, increase labor output, increase daily output, balance consecutive operations and increase management and workers relationship. In detail, there is in figure 1.

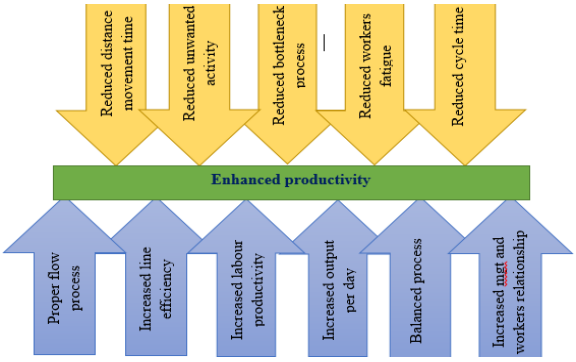

Fig. 1**.** Overall ways of enhancing productivity.

For cutting section: In the cutting section unwanted movements are upper collect and insole collect are canceled and direct to merge with the next operation also the upper raw material distance is reduced by 3m and the reduced distance is 60m – 48m = 12m and 240second – 192second = 48secnd. The rearranged flow process is prepared according to smooth and balanced the process with less movement of workers during the time and also in each operation process arrangements are considered of types of operation especially by manual (on a table) or machine, working environment, and another model of operation.

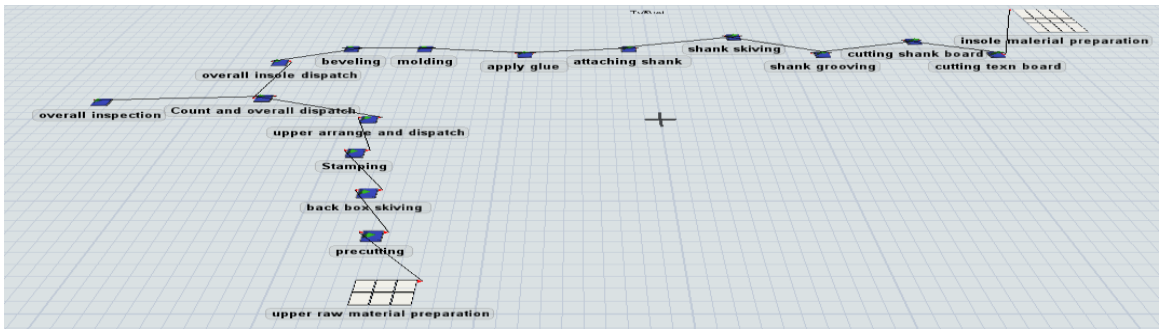

Fig. 2**.** Proposed process flow and arrangements of the cutting section

In the cutting section, most of the consecutive operation processes are worked by using different machines, in case that, it is impossible to emerge the process and only balancing the number of workers on the line of the operation process. Then, in upper collect, back box skiving, beveling and insole collect 5 labor are reduced and add one (1) labor in upper raw material preparation and shown in table 6 bellow

Table
Proposed capacity output, reduced bottleneck, and labor with cycle time after balanced Process of cutting section**.**

Operations	**ST**	**Capacity per day**	**Labour**	**CT**
upper raw material preparation	53.88	1069.14	2	26.938
pre-cutting operation	61.96	929.68	2	30.978
back box skiving	40.97	702.99	1	40.968
stamping	61.73	933.07	2	30.866
upper arrange and dispatch	65.10	884.80	2	32.550
insole material preparation	33.78	852.47	1	33.784
cutting texn board	33.67	855.31	1	33.672
cutting shank board	32.77	878.74	1	32.774
shank grooving	31.65	909.90	1	31.652
shank skiving	35.13	819.79	1	35.131
attaching shank	28.85	998.42	1	28.846
apply glue	34.79	827.72	1	34.794
molding	32.33	890.95	1	32.325
beveling	31.65	909.90	1	31.652
insole arrange and dispatch	36.25	794.41	1	36.254
count and overall dispatch	31.43	916.40	1	31.427
overall inspection	37.82	761.40	1	37.825
Total	**683.77**		**21**	**562.435**

Reduced number of labour = existed number of labour – proposed = 25 – 21 = 4 labour is reduced and reduced cycle time = existed CT (sec) – proposed CT (sec) = 625.906 second - 562.435 second = 63.471 second pair shoe.
Line efficiency = [(562.435 second)/ (16 *40.968 second)] *100 = 80.76%.
Total output per day = (0.8076*21*28800)/ 683.77 second = 714 pair per day, Labour output per day = 714 pair per day / 21 = 34 pair per labour per day

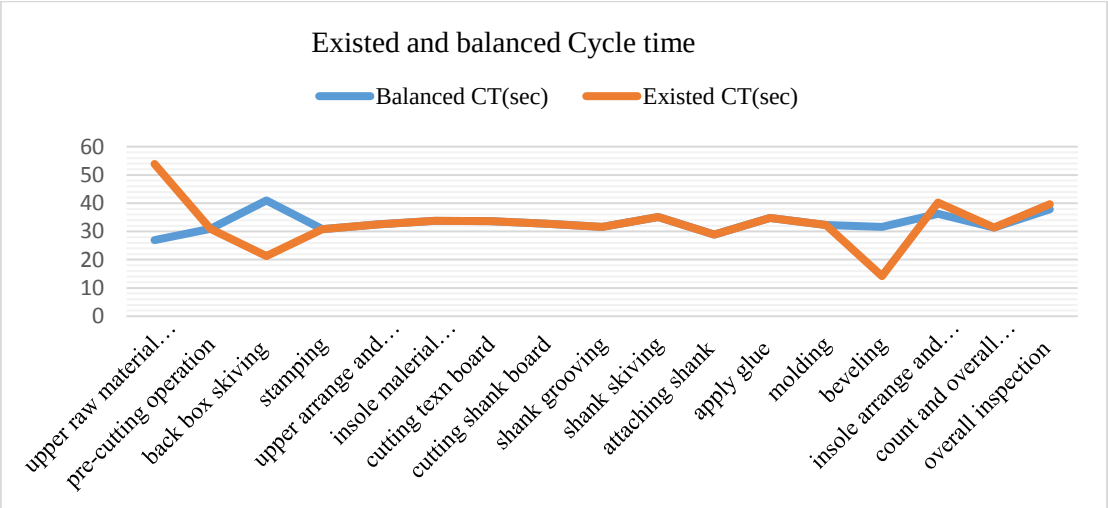

Fig. 3. Existed and balanced Cycle time of cutting section

For the stitching section: Due to assembling some of the processes those has bottleneck operations with labor the proposed distance movement 83.5m – 70.5m = 13m and 334 second – 282 second = 52 second, which means that 13m with 52 second is reduced in pair of the shoe production process and also the proposed of rearranged and number of the operation is 33 in figure 4.

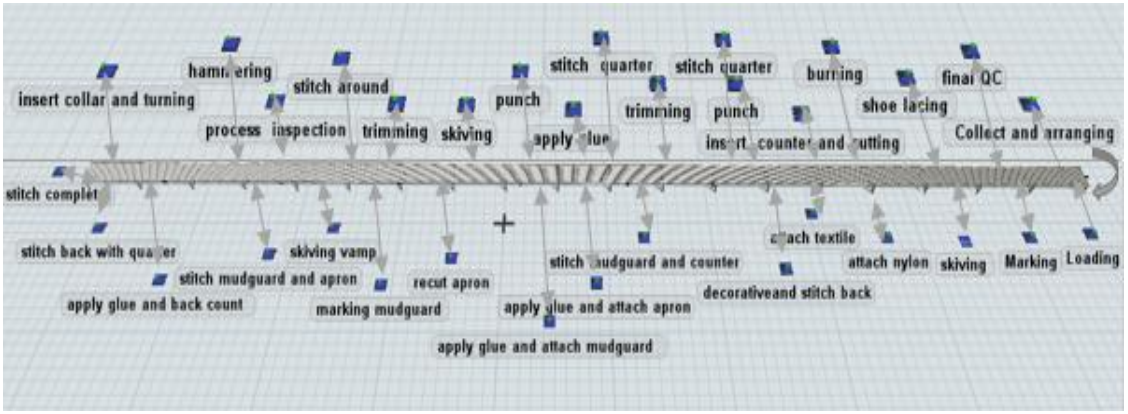

Fig. 4. Proposed process flow and arrangements of stitching section

Table 6
Proposed capacity output, reduced bottleneck, and labor with cycle time after balanced process of stitching section

Operations	**ST(sec)**	**Capacity**	**Labour**	**CT(sec)**
Loading	60.28752	955.422	2	30.144
Marking	75.3594	764.337	2	37.680
skiving and quarter lining	59.54454	967.343	2	29.772
attach nylon and reinforcement	55.61736	1035.648	2	27.809
attach textile adhesive	34.17708	842.670	1	34.177
decorative stitch on quarter and stitch back count lining	95.76	902.256	3	31.920
stitch mudguard lining and counter	37.8566	760.766	1	37.857
apply glue and attach apron	80.16	718.563	2	40.080
apply glue and attach mudguard	79.8	721.805	2	39.900
re-cut apron and mudguard	38.7411	743.397	1	38.741
marking mudguard	33.0803	870.609	1	33.080
skiving vamp with its lining	39.8025	723.573	1	39.803
stitch mudguard with mudguard lining and stitch apron with its lining	62.94	915.157	2	31.470

apply glue and attach back count	79.8	721.805	2	39.900
stitch back count with quarter	33.42	861.759	1	33.420
stitch complete quarter and quarter lining	58.377	986.690	2	29.189
insert collar foam by applying glue and turning	107.52	803.571	3	35.840
hammering around collar	32.88	875.912	1	32.880
in process quality inspection	32.4	888.889	1	32.400
stitch around eye stay and collar	59.11998	974.290	2	29.560
trimming around eye stay and apron	38.42268	749.557	1	38.423
skiving 45 degrees for mudguard	37.149	775.256	1	37.149
punch eyelet place	58.48314	984.899	2	29.242
apply glue and attach quarter	79.605	723.573	2	39.803
stitch quarter over mudguard	46.59546	618.086	1	46.595
trimming around the quarter lining	36.0876	798.058	1	36.088
stitch quarter lining bottom	33.9648	847.937	1	33.965
punch closed hole	41.3946	695.743	1	41.395
insert counter and applying glue and cutting and cleaning excess	123.96	696.999	3	41.320
burning the excess thread	37.149	775.256	1	37.149
temporary shoe lacing	38.2104	753.721	1	38.210
final QC	38.42268	749.557	1	38.423
Collect and arranging pairwise	38.2104	753.721	1	38.210
Total	**1804.29814**		**51**	**1181.591**

Line efficiency = [(1181.591)/33*46.595)] *100 = 76.8% and Total output per day = (0.768 *51*28800)/ 1804.29814 = 625.3 pair per day and Labour output per day = 625 pair/51 = 12.3 pair

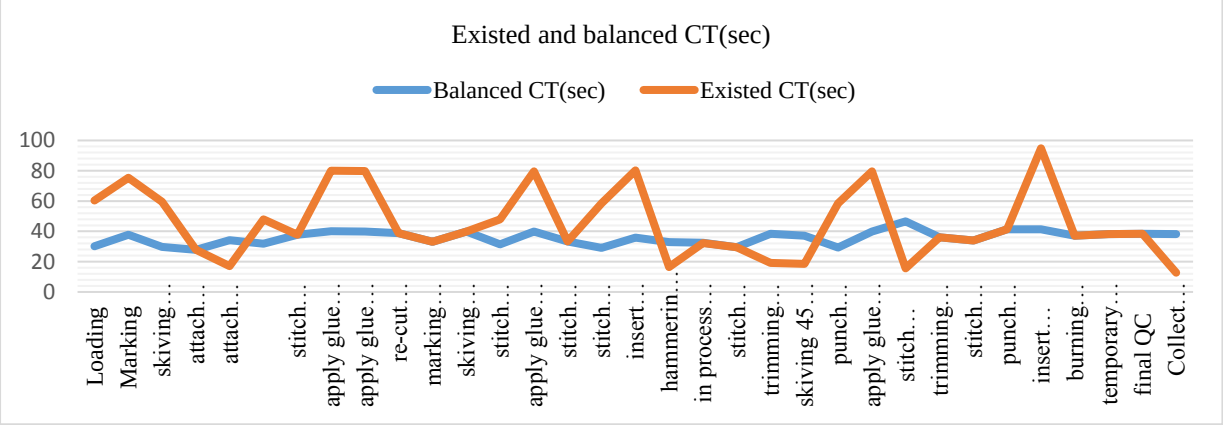

Fig. 5**.** Existed and balanced cycle time of stitching section

For lasting and finishing section: Due to assembling some of the processes those has bottleneck operations with labor the proposed distance movement 83m – 74m = 9m and 332 second – 296second = 36 second and also the proposed rearranged and the number of the operation is 33, figure 6.

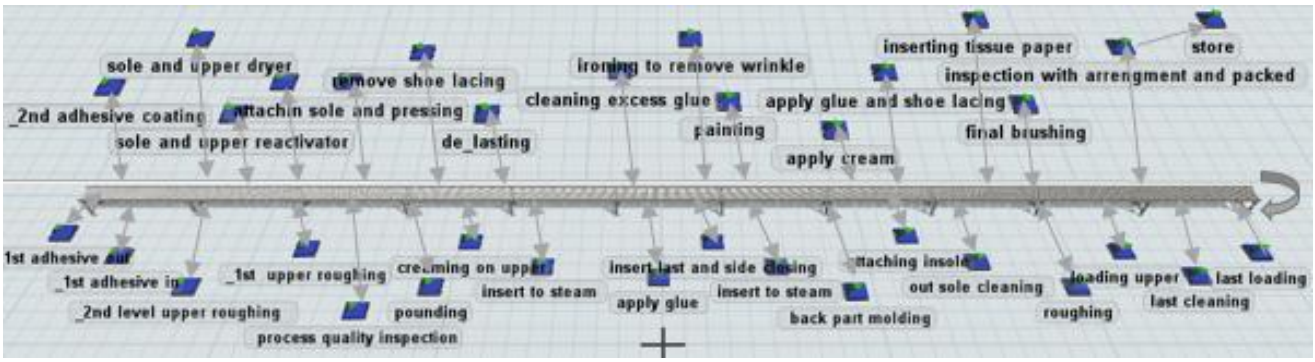

Fig. 6**.** Proposed process flow and arrangements of lasting and finishing section

Table 7
Capacity output, reduced bottleneck, and labor with cycle time after balanced process of lasting and finishing section

Operations	ST(sec)	Capacity	Labour	CT(sec)
last loading and insole	63.68835	904.404	2	31.844
last cleaning	32.21262	894.060	1	32.213
loading upper, toe cap steel	58.53012	984.109	2	29.265
roughing around the center of the outsole	38.9499	739.411	1	38.950
out sole cleaning	37.8972	759.951	1	37.897
attaching insole on last	32.00208	899.942	1	32.002
back part molding	58.21431	989.447	2	29.107
insert to steam	38.9499	739.411	1	38.950
insert last and side closing	69.4782	829.037	2	34.739
apply glue on the sides of the upper	38.10774	755.752	1	38.108
insert to steam	58.42485	985.882	2	29.212
creaming on upper and inserting in heat tunnel	63.89889	901.424	2	31.949
Pounding	32.10735	896.991	1	32.107
in process quality inspection	37.37085	770.654	1	37.371
first level upper roughing	36.00234	799.948	1	36.002
second level upper roughing	38.73936	743.430	1	38.739
first adhesive coating on upper	68.63604	839.209	2	34.318
the first adhesive coating on our sole	38.9499	739.411	1	38.950
the second adhesive coating on the upper and sole	37.16031	775.020	1	37.160
sole and upper dryer	35.26545	816.663	1	35.265
sole and upper re-activator	36.8445	781.663	1	36.845
attaching sole with upper	64.53051	892.601	2	32.265
attaching sole with upper and pressing	106.11216	814.233	3	35.371
remove temporary shoe lacing	38.00247	757.845	1	38.002
de-lasting	46.95042	613.413	1	46.950
cleaning excess glue	69.68874	826.532	2	34.844
ironing to remove wrinkle	63.162	911.941	2	31.581
painting on over the rough place	36.8445	781.663	1	36.845
apply cream on upper	33.47586	860.321	1	33.476
apply glue and insert sock lining and shoe lacing	117.6	734.694	3	39.200
inserting tissue paper	64.2147	896.991	2	32.107
final brushing for shine	37.26558	772.831	1	37.266
final quality inspection and arrangement and pack	81	711.111	2	40.500
Total	**1710.2772**		**49**	**1169.402**

Line efficiency= [(1169.402)/(33*46.950)] *100 = 75.5% and Total output per day =(0.755*49*28800)/ 1710.2772 = 623 pair and Labour output per day = 622.9pair /49 = 12.7 pair per day per labour.

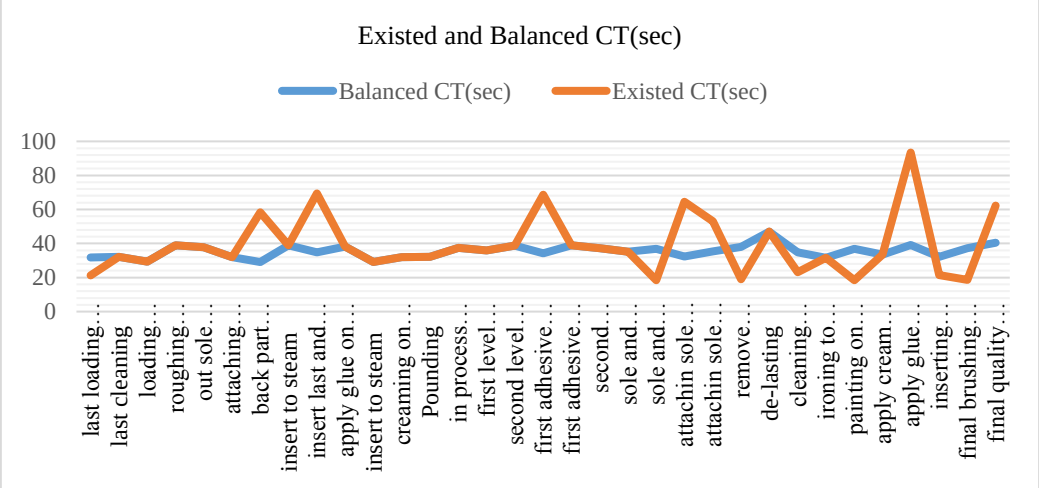

Fig. 7. Existed and balanced cycle time of lasting and finishing section.

6. Conclusion

Overall the study is focused on the enhancement of the productivity of the footwear industry in the selected company through reducing factors that affect productivity and enhancing the overall productivity of the company by using work measurement and line balance techniques. The result of the study is a reduced total of unwanted movement distance with a time, cycle time, number of operations (station), and number of the labor from the existed is 34m with 136 seconds, 498.19second, 8 number operations, and 9 labor respectively and also it increased line efficiency of the cutting, stitching and lasting and finishing section to

80.76%, 76.8%, and 75.50% and output per day in pair are to 714, 625.3 and 623 with the increased labor productivity per day in pair to 34, 12.3 and 12.7 respectively. Generally, the company enhanced productivity of finished footwear output is 623 pairs per day with an additional output of 160 pairs of shoes per day and the actual finished shoe output performance of the company is increased by 23%.

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